

ABSTRACT

Carbon Monoxide-A useful tool for the control of unburned carbon and Low NO_x burners

In a coal fired boiler, poor distribution of combustion air is typically indicated by an increase of unburned carbon in the flyash. In a standard application this unburned carbon, is not usually accompanied by a significant amount of carbon monoxide.

In a Low NO_x application, this unburned fuel is typically accompanied by an increase in bulk Carbon Monoxide concentrations in the flue gas. When CO is monitored in conjunction with flue gas oxygen, it can provide valuable feedback to the boiler operator and allow them to diagnose combustion irregularities. This will provide an effective method to monitor unstable combustion conditions that may create an increase in unburned carbon and improve the overall efficiency of the process.

This paper highlights the application of the latest technologies available to monitor these flue gas parameters, on a reliable and continuous basis.

Introduction

In the past there have been studies that have shown the measurement of carbon monoxide in a coal fired boiler could not be used to improve efficiency, since the LOI levels increased before any CO was present in a detectable level. Since that time these plants have installed Low NO_x burners.

In order to have the ability to react to changes in the stability of Low NO_x flames, and hence increased potential for high LOI, the operator must have a tool, or sensor for the on line measurement of either LOI or CO. Traditionally, the technologies for LOI measurement have been limited to inferred measurements, or long term sampling methods. Most of these methods have proven to be high capital cost items, and maintenance intensive.

Conversely, the technology for the measurement of Carbon Monoxide, has improved substantially over the years, to the point where the operator can use the CO sensor output for short term burner diagnostics and indication of combustion instability.

The application and use of this technology is dependent on the firing configuration of the boiler (i.e. corner fired, wall fired etc.) and the boiler load conditions.

Summary

Several studies were done in the mid 1980's showing the application and use of CO as a combustion parameter on coal fired boilers. As you can see (figure 1) when the excess air is reduced, the LOI concentration begins to change substantially, before any carbon monoxide is detected. This change dramatically increases the fuel loss in the process and hence the oxygen levels were set to operate at higher levels, in this application.

In a low NO_x burner application, the CO levels are increased at an earlier point (figure 2) and the LOI changes, follow a similar trend.

This early occurrence of CO can probably be attributed to the formation of the CO in the early stages of Low NO_x burning, where the burner is starved for air, before the secondary air is entered into the process.

Since CO has become a useful parameter to monitor in this application one must ask, what technologies are available, and can they provide a reliable sensor output for this application.

Installation Location

The Selection of installation location is an important part of CO monitoring for Low NO_x burner efficiency optimization and feedback to control unburned carbon in ash. It should be as close to the combustion zone as possible, while meeting the criteria below:

1. CO level must be able to be measured continuously
2. The measurement must not be adversely affected by stratification in the flue gas.
3. The measurement must have a rapid response to changes in the flue gas CO concentrations.
4. The analyzer should be installed in an accessible area.

Process Gas Considerations

As an optimum the analyzer would be installed in the furnace and CO concentrations measured in the furnace zone. However none of the available techniques will operate in this area on a continuous basis.

The next logical position for the measurement is after the economizer. The advantage of this point is that it is very close to the furnace. The disadvantage is that the application point has high dust concentrations and high temperatures. This would limit the analytical technique used to an extractive type measurement.

If the application would allow installation of the measurement device after the air pre-heater, a point insitu device may be used as well as the extractive type analyzers.

All of the technologies may be installed after the ash collector device.

Process Gas Considerations

Location	Dust	Temperature	Analytical Technique
Economizer outlet	High	High	Extractive
Air Heater outlet	High	Medium	Extractive Point Insitu
Ash Collector	Low	Low	Extractive Point Insitu Cross-Duct Insitu

	Multi-Point	Single Point
Dilution Extractive	Option	YES
Extractive	Option	YES
Insitu-point	NO	YES
Insitu- Cross Duct	YES	NO

Response Time Considerations

It is important to not select the measurement technique based on the conditions of the measurement, but to select the measurement point, which meets the requirements for the application.

Response Time

The response to changes in the process is critical. The optimum measurement would be to have a rapid response time as close to the process as possible. Unfortunately the technology and the location do not match that perfectly. If we break response time into three different categories we can then analyze the best technology Vs location match.

Analyzer Lag Time

The analyzer lag time is the time it takes from the point of measurement, until the gas sample is introduced to the measuring/sensor area.

Analyzer Response

The analyzer response is calculated from the time the gas reaches the sensor or detector. Until the analyzer outputs reaches 90% of its final value.

Process Lag Time

The process lag time is the time it takes one gas particle to go from the Economizer outlet to the point of measurement.

	Process Lag Time	Analyzer Lag Time	Analyzer Response Time	Total Response Time (Process Change)
	Seconds	Seconds	Seconds	Seconds
Dilution Extractive	00	60	01	61
Extractive	00	60	20	80
Insitu Point	<02	05 (cell purge time)	05	<12
Insitu-Cross	<02	00	02	<04

Duct				
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After analyzing the Total Response time a decision can be made on the selection of which response time is acceptable to the user.

CO Monitoring Technologies Available

There are several measurement technologies available for CO measurement. Each of these technologies has their benefits and applicability in specific applications. Generally, we can break the methods into two categories - Insitu monitoring and Extractive monitoring.

As a rule, extractive technologies include all instrumentation which draw a sample of gas out of its environment (i.e., the stack or duct work) and into an analyzer for measurement. In-situ monitoring is broadly seen as any monitoring done directly at the source location without removing the gas from the process.

The starting point of this analysis should be whether to use extractive type monitoring or in-situ monitoring to obtain the best quantitative results. Both extractive and in-situ monitors have high quality electronics used for the measurement of the gas and both types are generally viewed as accurate in providing results based on the samples that are brought to them. This means that the most significant differences come to light when examining the means by which each type of system gets its gas sample.

The in-situ type gas analyzer gets its “gas sample” instantaneously as the gas passes it on the way through the process. Therefore, the sample is analyzed in “as is” condition and is measured in real time value.

The extractive sampling systems draw a sample out of the stack, through a conditioning process of filtering, water knock-out, or dilution, and into the analyzer for measurement. This sample is analyzed with a “lag time” attached to it.

Technology Summary

From the above application considerations the table below summarizes the technology applications as they relate to the requirements for combustion monitoring of carbon monoxide

	Rapid Response Time	True Insitu Measurement	Low Periodic Maintenance	Affected by Flue gas Stratification
<i>Insitu-Cross Duct</i>	YES	YES	YES	NO
Dilution Extractive	NO	NO	NO	Yes
Extractive	NO	NO	NO	Yes
Insitu Point	Yes	NO	NO	Yes

The latest technology for cross duct insitu monitoring

The following describes the latest technology available for cross duct insitu monitoring.